
THE CODE
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BBC

OUR CHALLENGE

Solve the six puzzles on the cards and then visit OpenLearn to unscramble a clue to The Code treasure hunt.

www.open.ac.uk/openlearn/thecode

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WHAT IS THE SEVENTH
PRIME NUMBER?

PRIME NUMBERS

A prime number is a whole number greater than 1 that is divisible only by itself and 1. For example, 7 is a prime number because it is divisible only by 7 and 1, but 9 is not a prime number because it is divisible by 3. The first seven prime numbers are 2, 3, 5, 7, 11, 13 and 17. Around 300 BC the Greek mathematician Euclid proved that there are infinitely many prime numbers. He also proved that every whole number greater than 1 can be obtained by multiplying prime numbers together. For instance, $60=2\times2\times3\times5$.

Magicicadas

Magicicadas are North American cicadas that live immobile underground for many years, before emerging as a group to breed. Some colonies emerge every 13 years, while others emerge every 17 years. These prime number cycles may have evolved to reduce interbreeding of different colonies.

Magicicada
by Alice Jones © BBC

Euclid in Raphael's School of Athens

Goldbach's conjecture

In 1742 the German mathematician Christian Goldbach conjectured that every even whole number greater than 2 is the sum of two prime numbers. For example, $4=2+2$ and $10=3+7$. Today Goldbach's conjecture is one of the most famous unsolved problems in mathematics.

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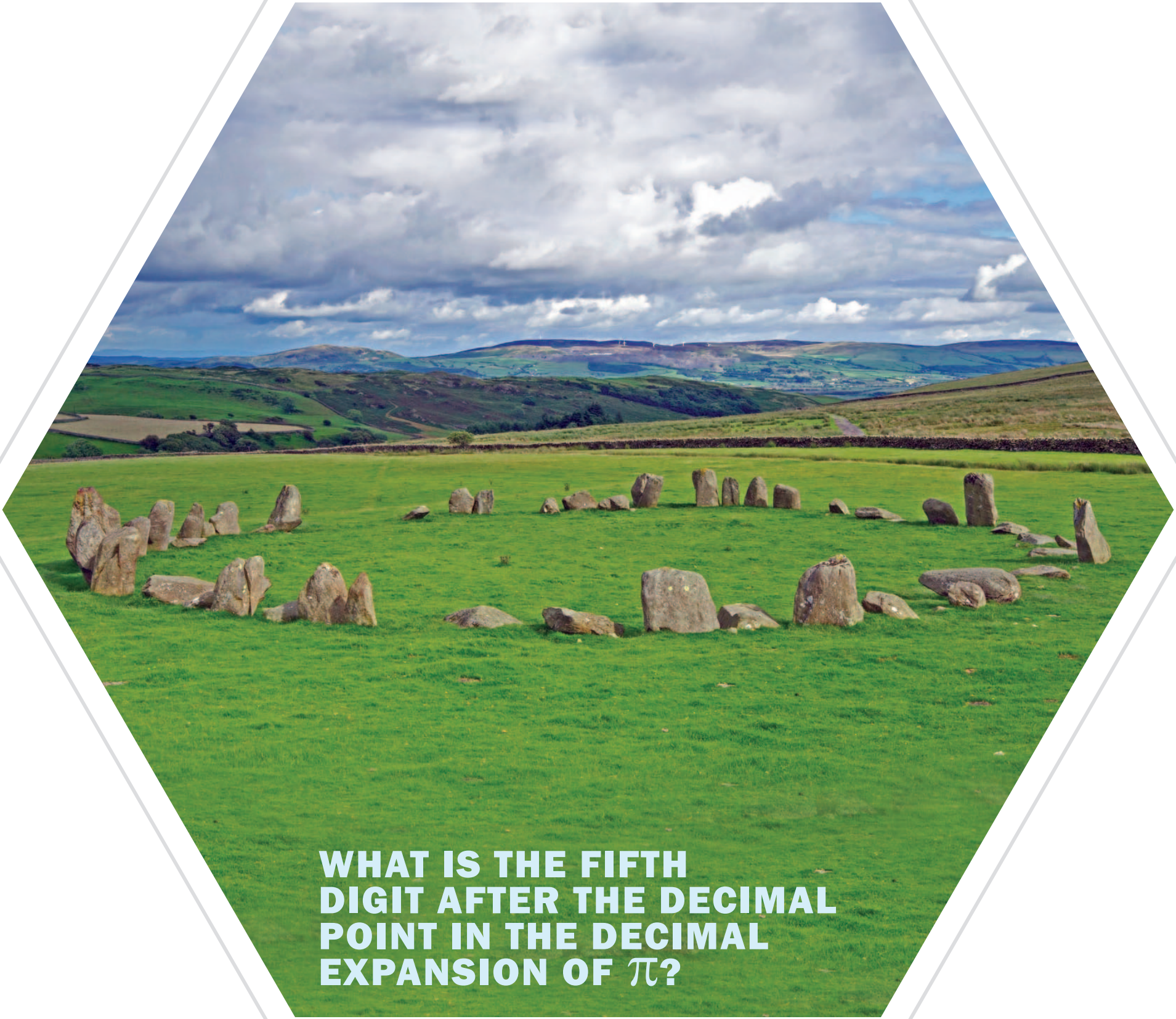
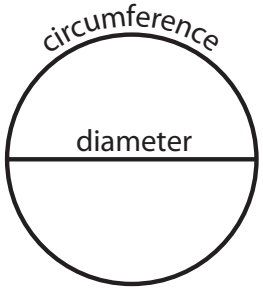

WHAT IS THE FIFTH
DIGIT AFTER THE DECIMAL
POINT IN THE DECIMAL
EXPANSION OF π?

PI



If you divide the circumference of a circle by its diameter, you always get the same answer, whatever the size of the circle. This number is known as pi, and is represented by the Greek letter π. It is equal to 3.14159... (there are infinitely many digits after the decimal point). The number π is close in value to the fraction $\frac{22}{7}$, but it is irrational, which means that it cannot be expressed exactly as a fraction.

Euler's identity

One of the most celebrated mathematical equations is Euler's identity $e^{i\pi}+1=0$. The magnificence of this equation is that it brings together five fundamental numbers, namely 0, 1, e, i and π, in one simple equation. The number e is an important mathematical constant equal to 2.71828..., and i represents a square root of -1.

Leonard Euler

The mouse problem

Imagine a huge circular loop of string around the Earth's equator (assume the Earth is a sphere). You wish to lengthen the string so that it still encircles the Earth, but with a 2cm gap between the string and the Earth all the way round: just enough for a mouse to squeeze underneath. How much longer does the string need to be?
Visit www.open.ac.uk/openlearn/thecode for the solution.
(The mouse problem is not part of The Code treasure hunt.)

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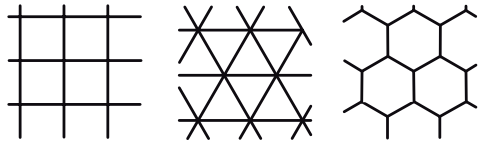
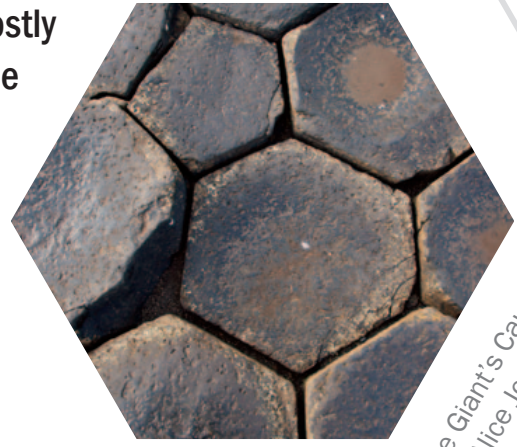
HOW MANY REGULAR TESSELLATIONS ARE THERE?

TESSELLATIONS

A tessellation is a collection of flat shapes that fit together, without gaps, to fill a region. Examples include the patterns made by floor tiles and bricks, and the mostly hexagonal tessellation of the Giant's Causeway. The three tessellations below, made of identical regular shapes, are called the regular tessellations.





The Giant's Causeway by Alice Jones © BBC

Honeycombs

In building their nests, honeybees create a hexagonal tessellation out of wax. It has been suggested that this structure minimises the amount of wax used. Another theory is that the hexagons arise naturally from cramming together many similar wax cells.

M.C. Escher

The Dutch artist Maurits Escher combined mathematics and art to create beautiful tessellations. Among his many great works are his Circle Limit wood engravings, which are based on a type of geometry known as hyperbolic geometry.

M.C. Escher's "Circle Limit IV"
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Honeycomb by Alice Jones © BBC

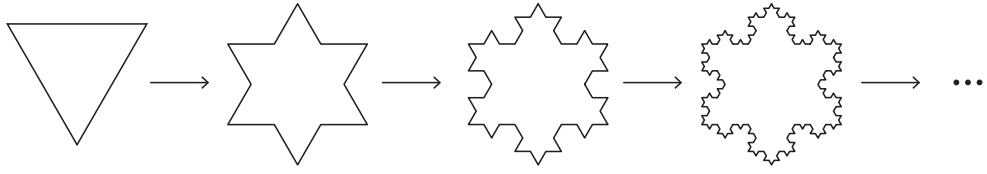
HOW MANY SIDES DOES THE THIRD SHAPE IN THE VON KOCH SNOWFLAKE CONSTRUCTION HAVE?

FRACTALS

A fractal is a complex shape made of smaller parts that each resemble the whole shape. These smaller parts are themselves made of even smaller parts that resemble the whole shape, and so on. Although fractals have been observed in mathematics for more than 100 years, the term 'fractal' was introduced only in 1975 by the French mathematician Benoit Mandelbrot. The development of computer graphics since then has led to an explosion in the creation and understanding of fractals.

The von Koch snowflake

Here is a step-by-step guide to creating the fractal known as the von Koch snowflake. Begin with an equilateral triangle. Replace each side of the triangle with a small copy of the jagged segment shown on the left. A new shape is obtained, with 12 sides. Next, replace each side of this new shape with more (smaller) copies of the jagged segment. Another shape is obtained, with 48 sides. Continue in this fashion. If the process is repeated infinitely many times then the resulting shape is the von Koch snowflake.



Ferns

A fern leaf has a fractal shape because its leaflets resemble miniature copies of the whole leaf. There are many other objects in nature with a fractal shape, such as mountains, snowflakes and cauliflowers.

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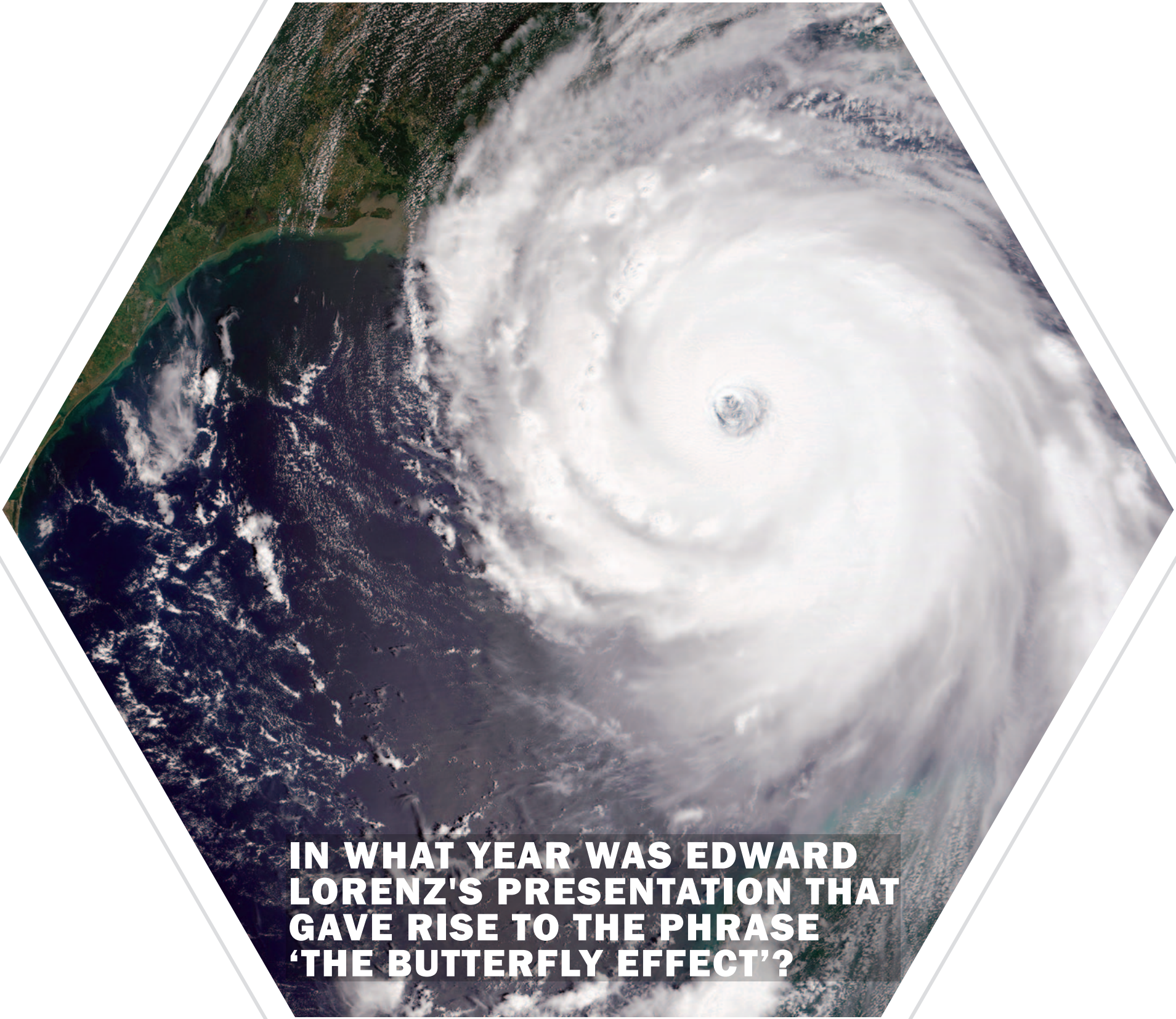
Fern by Alice Jones © BBC



IN WHAT YEAR WAS EDWARD LORENZ'S PRESENTATION THAT GAVE RISE TO THE PHRASE ‘THE BUTTERFLY EFFECT’?

CHAOS

Chaos theory is the study of systems that are extremely sensitive to small changes. One such system is the weather. The idea that a small disturbance in the weather may lead to a large change later is known as the butterfly effect. This phrase arose from a presentation by the meteorologist Edward Lorenz in 1972 entitled 'Predictability: does the flap of a butterfly's wings in Brazil set off a tornado in Texas?'

The three-body problem

In 1884, King Oscar II of Sweden and Norway sponsored a competition, one of whose challenges was to describe the motion of three or more bodies (such as planets or stars) under the force of gravity. The prize was awarded to the French mathematician Henri Poincaré who made important mathematical advances, but did not solve the problem. While correcting an error in his prize winning work, Poincaré discovered that the motion of three bodies under gravity may be chaotic. There are now believed to be many instances of chaos in our solar system. For example, it is likely that Pluto's orbit is chaotic.

Henri Poincaré

Double pendulum

A double pendulum consists of one pendulum attached to the lower end of another. When released from a suitable initial state its motion is chaotic.

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HOW MANY DOTS
ARE THERE ON A
PAIR OF DICE?

PROBABILITY

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The probability of an event is a number between 0 and 1 that expresses how likely it is that the event will occur. Events with probability 1 will certainly occur, events with probability 0 will not occur, and events with probability $\frac{1}{2}$ are equally likely to occur or not occur. For example, the probability of obtaining an even number from a single throw of a dice is $\frac{1}{2}$.

The Chevalier de Méré

Pierre de Fermat

The foundations of probability theory were developed in an exchange of letters from 1654 to 1660 between the French mathematicians Pierre de Fermat and Blaise Pascal. They were inspired by gambling problems posed by the writer known as the Chevalier de Méré. One of these problems asked whether you are likely to make a profit in betting that a double six will arise in twenty-four throws of a pair of dice. Fermat and Pascal proved that the answer is no. In fact the probability of throwing a double six with twenty-four attempts is approximately 0.49.

Blaise Pascal

Population estimation

One way to estimate the number of fish in a lake is to catch and mark 100 of them, release them, and then catch another 100. Probability calculations show that if, for example, there are 10 marked fish in the second catch of 100, then it is likely that there are about 1000 fish in total.

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